

Even though today most vendors build the PBXs around common available processors running common operating systems (such as UNIX) and use common programming languages (such as C or C++), unfortunately different vendors' switching devices use proprietary communication protocols. Thus, it is virtually impossible to integrate one vendor's switching device with other vendors' applications.

Therefore, it becomes highly desirable to provide a telecommunication system with a feature that would convert proprietary PBX or external application protocols into a common format, and thus would function as a "protocol interpreter" between proprietary switching system protocols and the protocols of various applications.

A number of solutions to that problem have been disclosed in the prior art. For example, U.S. Patent No. 4,873,718 "Feature Telephone Integration Device" issued to Barnett et al discloses a device and method for integrating one vendor's application (a voice mail system) into a PBX environment of a different vendor. In that patent the interconnection was achieved by equipping the PBX vendor's feature phone with additional circuitry to monitor telephone communication between the PBX, the feature telephone and the external application. An obvious disadvantage of the disclosed system is its inability to provide a generic interface between many possible proprietary protocols of different PBX switching systems and an external application. The disclosed invention provided integration only between a PBX and a voice mail system, it did not provide for the possibility to integrate a PBX with a variety of different external applications. Moreover, any exchange

VIRTUAL TELEPHONE

BACKGROUND OF THE INVENTION

5 1. Field of the invention

10 The present invention relates generally to a telephone communication system and, in particular, to a device that provides a generic software interface to a digital line on one of many different types of digital phone switches. A telephone with such a generic interface is a "virtual phone" that has the flexibility to represent the majority of features of any digital phone, regardless of the switch type or the number of
15 features in a digital phone.

20 The general concept of a virtual telephone has been in existence in various forms across different product lines. In some cases a virtual phone has been used to represent a specific digital phone, such as Rolm Phone 400 or a Meridian 2616. Those phones represent a superset of phones for their respective switches. In other cases a virtual phone has been used to represent only the necessary portions, or a subset, or a digital
25 telephone.

2. Prior Art

30 One of the important characteristics of a telecommunication system is the ability of different interconnected components of the system to effectively communicate with each other. Many business-oriented telecommunication systems have PBX (Private Branch Exchange) switches that link internal telephones with
35 each other and with external telephone networks.

of information about a call or a change of the status of the call occurs "one-way" only: from the PBX to the telephone set.

5 U.S. Patent No. 5,440,616 provides an improvement over the device of Patent No. 4,873,718 in the form of apparatus for interconnecting a messaging system (voice, facsimile, etc.) with a PBX which offers entirely digital transmission and provides high bandwidth and
10 redundant transmission of control information between the messaging system and the PBX. The apparatus of Patent No. 5,440,616 includes a digital voice terminal adapter which is a combination of hardware and software which emulates a digital feature phone and which
15 interconnects a messaging system and a PBX to provide full integration of the messaging system with the PBX. The disclosed adapter does not, however, convert proprietary/PBX or external application protocols into a common format and thus does not function as a protocol
20 interpreter between proprietary switching system protocols and the protocols of various applications.

U.S. Patent No. 5,255,314 "Switch Adjunct Integration Device" issued to Applegate et al discloses
25 a device that uses multiple line appearances of one or more digital telephone lines to gather information on calls designed for an adjunct voice mail system. After receiving the required information the device transfers the calls to analog phone lines leading to the voice
30 mail system. That device, again, provides no more than a communication tool between a PBX switch and a voice mail system. The disclosed device does not integrate any type of the known PBX switches with any type of external device via a generic interface.

SUMMARY OF THE INVENTION

Advantageously, the present invention overcomes the "protocol conversion" difficulties which existed in the prior art. The virtual phone generic interface of the present invention comprises three distinct modules: a virtual phone data structure, a program interface, and a host interface. All three modules can work independently of a specific type of integration. The data structure and the program interface software of the virtual phone are built into the embedded processor that controls the Private Branch Exchange (PBX) digital phone switching system interface integration. The interface between the switch and the virtual phone data structure is different for each integration, but once the interface is completed, it can be reused for many different types of applications. The interface between the virtual phone structures and the external application is the same regardless of the type of integration.

The implementation of the virtual phone provides for an external interface through any type of transport medium. A phone application residing on an auxiliary PC can show the current status of the virtual phone, and can also do call control. This illustrates the common external interface and also provides a method for diagnostics. The interface to the auxiliary PC is accomplished in different ways based on the system configuration. It can be done via a serial port, ISA bus, PCI bus, universal serial bus, Ethernet, or any other type of transport configurable. An internally designed protocol is used to communicate between the virtual phone and the auxiliary PC. In essence, the virtual phone acts as a protocol converter between the

proprietary switch messages and the external serial interface.

The virtual phone of the present invention provides a common interface between any of the digital phone switches and any number of end devices. The virtual phone represents the current state of some theoretical phone and has buttons, lights, a hook switch, display, ringer, and anything else typical of a standard digital phone. The main component of the virtual phone is a set of structures that represent the state of the phone at any given time. The virtual phone structures can be accessed via a set of Virtual Phone Application Program Interface (VPAPI) function calls. The virtual phone status and events are transmitted externally via a custom virtual phone host interface.

When a packet is received from a switch, an abstraction layer parses the data and calls an internal VPAPI function. The internal VPAPI function is responsible for updating the virtual phone structure and passing the information about any state changes to an auxiliary PC through the virtual phone host interface. An internally designed protocol is used to provide communication between the virtual phone and the auxiliary PC through the host interface such as a standard RS232 communications port. A phone application residing on the auxiliary PC can show the current status of the virtual phone and accomplish call control tasks. So, in essence, the virtual phone functions as a "protocol interpreter" between the proprietary switch messages and the external interface.

When an event is received from the auxiliary PC, an external VPAPI function is called to update the virtual

The foregoing and additional advantages and characterizing features of the present invention will become clearly apparent upon a reading of the ensuing detailed description together with the included drawing wherein:

Fig. 1 is a block diagram of the telephone communication system of the present invention;

Fig. 3 is a block diagram further illustrating the virtual phone application program interface of the systems of Figs. 1 and 2;

Fig. 5 is a block diagram illustrating a generalized form of the system of Fig. 1.

Telephone Communication System

Switch 12 can be a PBX, KSU, service provided by a central office (such as Centrex or ISDN) and does not even have to be digital. Digital telephone 14 is representative of other communication devices like phones using emerging network interface technologies like internet protocol (IP), isoehternet, various forms of wireless, ATM, etc. Various types of additional telephones (ex. switch dependent phones, analog phones, cordless phones, conference phones), modems, fax machines or computers can be connected to the primary communications device 14.

The actual virtual phone is represented by a set 20 of data structures, for example "C" language data structures that maintain the current status of the theoretical, i.e. virtual, phone. The data in these

The virtual phone structure 18 requires several bytes of RAM within the address range of an embedded microcontroller. The current state of the structures 20 matches what the switch 12 believes the digital phone 14 to be. Since it is possible for applications in processor 16 to take control away from the digital set 14, the virtual phone 20 and the digital phone 14 will not always have matching states. For example, if a digital phone and a cordless phone are connected to the same line, and voice is routed to the cordless, the switch thinks voice is active, and the digital phone does not.

The messages sent from the telephone switch 12 provide a representation of the state of the telephone 14 as it resides internally in the switch. The virtual phone 18 translates this state into a form that is not switch or phone dependent, but one that can represent any desired telephone or communications device. The virtual phone 18 is protocol and transport dependent.

The virtual phone system of the present invention is designed to fit the needs of different types of phone integration implementations. Of the three major components of the software system (Virtual Phone Structure 20, VPAPI 22, 24 and VPHI 26), not all need to be used in every system implementation. This is illustrated in the overview of Fig. 2.

In a first typical implementation, there is a case where the host interface is not needed. When an external communications device 34 is integrated into the system, the host protocol is unused. The external device 36 can be controlled directly from the system software within the micro-controller via the VPAPI 24 via an integrated link 38.

The auxiliary PC 16 from the arrangement of Fig. 1 is shown connected to host interface 26' via an RS232 link 40.

In another example, all three major components are used. The external communications device is a computer 44 with an ISA link 46 to the virtual phone system. This host computer 44 runs a TAPI application. As messages are received from the switch 12, the abstraction layer 28 calls VPAPI functions which update the virtual phone structures 20 and convert the commands into a generic protocol that can be easily understood by the host system 44. Optionally, the data does not even need to be maintained in the virtual phone structures. The system can act simply as a protocol converter.

Also shown in the example of Fig. 2 is a network application 50 linked to the virtual phone system via a TCP/IP protocol link 52.

The virtual phone data structures 20 of the virtual phone system 18 of Figs. 1 and 2 first will be described in detail, followed by description of the virtual phone application program interfaces 22, 24 and the abstraction layer 28. Accordingly, the following represents a description of all of the structures and

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Main Control Structure

```

typedef struct
/* Main Virtual Phone
Structure */
{
    VP_VOICE        voice;          /* voice status */
    VP_RINGER       ringer;         /* ringer status */
    VP_DISPLAY      display;        /*LCD display status */
    BYTE            num_buttons;     /* number of buttons
                                     actually in use */
    VP_BUTTON       button          /* button/lamp status */
        [VP_MAXBUTS];
    BYTE            StandAlone;      /* operate without
                                     digital set */
    BYTE            SwitchType;      /* type of switch
                                     connected */
    BYTE            DigSetType       /* Type of configured
                                     digital SET, if */
    BYTE            Connections;      /* Which Phone Units are
                                     physically connected */
    BYTE            ActivePhone;      /* Which Physical Phone
                                     Unit is active */
    BYTE            TouchedPhone;     /* Which Physical Phone
                                     Unit was last touched */
    BYTE            Carrier[2];       /* 0=switch 1=digital
                                     set */
    BYTE            PassThroughFlags; /* event block flags */
    BYTE            Voicemux;         /* Bearer channel
                                     direction */
};

```

```
BYTE    num_buttons;
```

The number of the virtual buttons actually in use by the virtual phone. Although the virtual phone can support many buttons, some applications may limit the number of buttons in use.

VP_BUTTON button [VP_MAXBUTS]; References the button control element of the virtual phone. This is described in greater detail in the section titled "Button/Lamp control structure".

BYTE StandAlone; When TRUE, the system is operating without an adjunct digital phone. When FALSE, an adjunct digital phone is connected and operating.

BYTE SwitchType; The brand of PBX (or KSU) connected to the system. The valid phone types are represented by the following defines:

#define	PBX_NONE	0	/* No PBX connected */
#define	PBX-ATT	1	/* AT&T switch connected */
#define	PBX_M1	2	/* Meridian switch connected */
#define	PBX_NORSTAR	3	/* Norstar switch connected */
#define	PBX_ROLM	4	/* Rolm switch connected */
#define	PBX_ISON	5	/* ISON switch connected */

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```

BYTE          Connections;      A mask of all of the
                                physical phone
                                connections made to
                                the system. Multiple
                                phones may be
                                connected at any time.
                                If the bit represented
                                by the following
                                defines is set in this
                                field, the associated
                                unit considered
                                connected.

#define        PHONE_NONE      0x00 /* No phones connected
                                */

#define        PHONE_ADJUNCT 0x01 /* the Standard digital
                                set */

#define        PHONE_AUX       0x02 /* phone app via debug
                                port */

#define        PHONE_CONF      0.04 /* conference speaker
                                phone */

BYTE          ActivePhone;      Identifies which
                                physical phone unit is
                                currently active. A
                                phone is defined to be
                                active if it has
                                control of the voice
                                channel. The valid
                                values for this field
                                are the same as those
                                defined for the
                                "Connections" field
                                above.

```

BYTE	Carrier [2]	Identifies the carrier status of the switch and the phone. The first set of defines indexes the unit, the second set represents the status.
------	-------------	---

```
#define CARRIER_DEVICE_SWITCH 0/* switch device */

#define CARRIER_DEVICE_ADJUNCT 1/* phone carrier device */

#define CARRIER_LEVEL_LOSS 0/* No carrier */

#define CARRIER_LEVEL_GAIN 1/* Carrier */

#define CARRIER_LEVEL_UNKNOWN 2/* Unknown carrier state */
```

BYTE PassThroughFlags A bit mask used to inform the abstraction layer which types of events should be passed between the switch and the phone, and which should be blocked.

#define PASS_HOOK 0x01 /* hook switch from set */

#define PASS_BUTTON 0x02 /* buttons from set */

#define PASS_LAMP 0x04 /* lamp updates from switch */

#define PASS_DISPLAY 0x08 /* display update switch */

#define PASS_RINGER 0x10 /* ring updates switch */

BYTE VoiceMux; Identifies the direction of each of the available bearer channels. This is a bit mask with each bit representing each of the channels.

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There is typically one bit for the voice channel, and at least one bit for available data channels. When the bit is low, the channel is directed to the adjunct digital telephone. When the bit is high, the channel is directed to the alternate device.

```
#define      VMUX_ADJUNCT      0      /* channel to
                                   digital set */
#define      VMUX_AUX          1      /* channel to
                                   alternate */
#define      VMUX_VOICE        0x01   /* bit 0 :  voice
                                   channel */
#define      VMUX_DATA          0x02   /* bit 1 :  1st
                                   data channel */
#define      VMUX_DATA1        0x02   /* bit 1:  1st data
                                   channel */
#define      VMUX_DATA2        0x04   /* bit 2 :  2nd
                                   data channel */
```

Voice control structure

The following "C" language code defines the structure used to represent the state of the voice channel. A single instance of this structure is built into the main virtual phone structure.

```
typedef struct                      /* Virtual Phone Voice
                                   Structure */
```

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```
BYTE          active;          /* 1=active 0=not active
                                */

BYTE          unit;            /* mask active unit
                                VOICE_???? */

BYTE          volume;          /* voice mute, low, high,
                                etc. */

VP_VOICE
BYTE          active;          When TRUE, the voice
                                path is currently
                                active.  When FALSE, the
                                voice path is not
                                active.

BYTE          unit;            Which unit (within the
                                confines of the digital
                                set) is currently used
                                as the communications
                                source.

#define        VOICE_HANDSET    0x10    /* Phone Handset
                                Unit */

#define        VOICE_SPEAKER    0x20    /* Phone Speaker
                                Unit */

#define        VOICE_HEADSET    0x30    /* Phone Headset
                                Unit */

BYTE          volume;          The current sound level at
                                which the system is
                                operating.

#define        VOICE_MUTE        0x01    /* Volume is muted
                                */

#define        VOICE_NORMAL      0x02    /* Volume is normal
                                */

#define        VOICE_LOW         0x03    /* Volume is low */

#define        VOICE_HIGH        0.04    /* Volume is high
                                */
```

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The following "C" language code defines the structure used to represent the ring state of the virtual phone. A single instance of this structure is built into the main virtual phone structure.

```
typedef struct                                /* Virtual Phone
                                             Ringer Structure
                                             */
BYTE          active;                        /* 1:active 0=not
                                             active */
BYTE          cadence;                      /* list of
                                             current cadence
                                             type */
BYTE          tone;                         /* list of
                                             current tone type
                                             */

VP_RINGER;

BYTE          active;                        When TRUE, the ring state
                                             of the virtual phone is on.
                                             Typically, an audible ring
                                             indication can be heard.
                                             When FALSE, the ring state
                                             is off.
BYTE          cadence;                      One of the many difference
                                             types of ring cadence
                                             patterns a phone may
                                             select. This is valid when
                                             the ring state is active.

#define RINGER_CAD_OFF 1                    /* ring off */
#define RINGER_CAD_ON  2                    /* ringer on steady */
```

```
#define    RINGER_CAD_2      3    /* ringer some on/off
                                   comb. */
```

```
BYTE      tone;      Once of the many different ring tones
                      a phone may select.  This is valid
                      when the ring is active.
```

```
#define    RINGER_TONE_OFF  1    /* tone off */
#define    RINGER_TONE_A    2    /* tone A */
#define    RINGER_TONE_B    3    /* tone B */
#define    RINGER_TONE_C    4    /* tone C */
#define    RINGER_TONE_D    5    /* tone D */
#define    RINGER_TONE_E    6    /* tone E */
#define    RINGER_TONE_F    7    /* tone F */
#define    RINGER_TONE_G    8    /* tone G */
#define    RINGER_TONE_H    9    /* tone H */
```

Display control structure

The following "C" language code defines the structure used to represent the LDC display of the virtual phone. A single instance of this structure is built into the main virtual phone structure.

```
typedef struct                                /* Virtual Phone
                                             Display Structure */
BYTE      grid [VP_MAXROWS]                /* The display text
                                             [VPD_MAXCOLS]; */
VP_CURSOR cursor                            /* current cursors*/
                                             [VPD_MAXCURSORS];
BYTE      NumRows;                          /* Number of Rows on
                                             this page */
```

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```

BYTE          NumColumns;          /* Number of Columns
                                     on this page */
BYTE          NumCursors;          /* Number of
                                     available cursors */
BYTE          IsStable;            /* True if the
                                     display has
                                     stabilized */
BYTE          IsClear;            /* True if the
VP_DISPLAY;                                     display is clear */

BYTE          grid [VPD_MAXROWS]  The 2 dimensional
    [VPD_MAXCOLS];                array containing the
                                     characters on the
                                     display of the
                                     virtual phone. Each
                                     cell of the grid
                                     contains the
                                     character value in
                                     ASCII format.
                                     VPD_MAXROWS and
                                     VPD_MAXCOLS can be
                                     defined to support
                                     virtual displays of
                                     various sizes.

```

```
BYTE IsClear;
```

True if the display
is clear.

The following "C" language code defines the structure used to represent a cursor device of the virtual phone. The display functions may use several cursors which must be maintained in order to generate the correct display. This structure is part of the main display structure.

```
typedef struct                                /* Virtual Phone
{                                              Cursor Structure */
    BYTE row; /* Current row for
              this cursor */
    BYTE col; /* Current column for
              this cursor */
}VP_BUTTON;
BYTE row; Current row for this
          cursor within the
          current display.
BYTE col; Current column for
          this cursor within
          the current display.
```

Button/Lamp control structure

The following "C" language code defines the structure used to represent a button/lamp device of the virtual phone. The main virtual phone structure uses a list of these items to represent all of the possible buttons/lamps on the phone.

```
typedefstruct                                /* Virtual Phone
                                              Button/Lamp Structure
                                              */
    BYTE deviceMask; /* mask showing which
                      of next 4 are valid
                      */
    BYTE press ID; /* ID of button press
                    info */
    BYTE release ID; /* ID of button
                      release info */
    BYTE lamp1ID; /* ID of first lamp
                  */
    BYTE lamp2ID; /* ID of second lamp
                  */
```

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```
BYTE          buttonState;      /* state of button:
                                1=down 0=up */

BYTE          lamp1State;       /* state of first
                                lamp */

BYTE          lamp2State;       /* state of second
                                lamp */

VP_BUTTON;

BYTE          deviceMask;       A mask which
                                identifies the
                                available components
                                of the button/lamp.
                                In some cases, button
                                may exist without a
                                lamp, in others, 2
                                lamps may relate to a
                                single button. Also,
                                some buttons have
                                press and release
                                codes, while others
                                only have a press
                                code. This mask
                                validates the fields
                                "pressID",
                                "releaseID",
                                "lamp1ID", and
                                "lamp2ID" by setting
                                the associated
                                defined bit.

#define        VDP_MASKPRESS    0x01 /* "pressID" is
                                valid */

#define        VDP_MASKRELEASE  0x02 /* "releaseID"
                                is valid */

#define        VDP_MASKLAMP1    0x04 /* "lamp1ID" is
                                valid */
```

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#define	VDP_MASKLAMP2	0x08 /* "lamp2ID" is valid */
BYTE	pressID;	The raw integration dependent ID sent to the switch when the button is pressed. This field is only valid when the VDB_MASKPRESS bit is set in the "deviceMask" field. Typically, all keys have this field active.
BYTE	releaseID;	The raw integration dependent ID sent to the switch when the button is released. This field is only valid when the VDB_MASKRELEASE bit is set in the "deviceMask" field. Typically, keypad buttons do not use a release ID.

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BYTE

lamp1ID;

The raw integration dependent ID sent by the switch during a lamp update. This field is only valid when the

VDB_MASKLAMP1 bit is set in the

"deviceMask" field.

Buttons that do not have associated

lights (such as keypad buttons) will not use this field.

BYTE

lamp2ID;

The raw integration dependent ID sent by the switch during a lamp update. This field is only valid when the

VDB_MASKLAMP2 bit is set in the

"deviceMask" field.

AT&T is the only integration known to use a second lamp for a button/lamp device.

00000000 00000000 00000000 00000000

[illegible]

In the main virtual phone structure, the field "VP_BUTTON button [VP-MAXBUTS]" is used to store the button/lamp information for the virtual phone. The define VP_MAXBUTS determines the maximum number of buttons/lamps the virtual phone can contain. There are standard buttons in all configurations of the virtual phone. There are also additional buttons that may vary from phone to phone. The values shown below define the indices into the array of button/lamp control structures within the main virtual phone.

```
#define KEY_HOOK 0 /* Hook switch key
*/

#define KEY_HOLD 1 /* Hold key */

#define KEY_XFER 2 /* Transfer key */

#define KEY_RELEASE 3 /* Release key */

#define KEY_PAD 4 /* Key Pad 0-9, *,
# */

#define KEY_NONFIXED 16 /* -start of non-
fixed buttons - */

#define KEY_PRIME 16 /* Prime Line */

#define KEY_OTHER 17 /* */
```

KEY_HOOK	The hook switch. When pressed, it is considered off hook. When released, on hook. All integrations have this key.
KEY_HOLD	The standard hold key. All integrations have this key.
KEY_XFER	The transfer key. All integrations have this key.
KEY_RELEASE	The release key. All integrations have this key.

KEY_PAD	The start of the key pad keys. The sequence of keys are in the following order. 0 through 9, *, and #. All integrations have these keys.
KEY_NONFIXED	The starting ID of the non-fixed keys. Keys at this index for higher can be custom configured.
KEY_PRIME	The key associated with a prime line. When the switch has a prime line configured for a phone, this index should reference that key.
KEY_OTHER	Additional keys. Configuration is flexible.
VPAPI	(Virtual Phone Application Program Interface)

Access to the virtual phone structures is available through a set of symmetric functions known as the VPAPI 22 and 24. The VPAPI 22, 24 provides a mechanism to transfer data between the virtual phone data structures 20, and all devices (such as the switch 12, phones 14, and the external device 16). The data structures 20 are changed only via this interface, never directly by an external function 16. All elements of the data structures 20 can be modified, and read through the VPAPI 22, 24. Whenever the abstraction layer software 28 receives a change from the switch 12, digital phone 14, or external device 16, a call is made to a VPAPI function with parameters specifying the update request. The VPAPI function first validates the command request, and then makes the appropriate modification to the virtual phone structure.

As shown in Fig. 3, for different switches 12a, 12b, 12c and 12d and phones 14a, 14b, 14c, 14d from various

vendors different abstraction layers 28a, 28b, 28c and 28d are provided. The VAPI 22, 24 also provide data transfer between the virtual phone data structures 20 and various devices such as serial devices 60, DSP 62, conference phones 64 and other devices 66.

Whenever a valid state change is made to the virtual phone structure 20, the VPAPI 24 calls a second function which is responsible for converting the information into a generic protocol (Host Interface 26), and transmitting it via the host interface 16 to the host system.

The abstraction layer 28 (and external device queries) often need information on the current state of the virtual phone. Symmetric VPAPI 22, 24 functions are used for this purpose and for all aspects of data access. In order to retrieve current status information and pass that information to the abstraction layer 28 and an external device 16, a function beginning with "vp_Get" is used. To modify data, "vp_Set" is used, which in turn automatically calls a function beginning with "vp_Send" for external transfer. Or, for example, to set a light state in the virtual phone structure, a call is made to "vp_SetLampState" with the lamp ID and state as parameters. For the abstraction layer 28 or external device 16 to get the light state, a call to the symmetric function "vp_GetLampState" is made.

The abstraction layer 28 (and external device queries) often need information regarding the current state of the virtual phone. Symmetric VPAPI functions are available for this purpose. Thus, during the processing of switch and phone packets, the abstraction layer 28 often calls the VPAPI functions 22, 24 to maintain current status of the digital phone 14 in the virtual phone data structures 20.

Primarily, the "vp_Set" type functions are used. When a simulated event occurs, such as a generic cordless unit going off hook, the application code may also make a call to the "vp_Set" function, causing the system to be in the off hook state. Also note that in order for the simulated event to affect the switch, it must pass through the abstraction layer through an API function of the form "vprolm_DoButton" for example.

The hardware abstraction layer 28 is not part of the virtual phone, but is a system component used to interface between the switch 12 (and phone 14) and the virtual phone 18. The specifications for building this block vary for each switch type. In the example of Fig. 4, building of an ISDN integration is shown for use with an ISDN switch 72 and ISDN phone 74.

The first layer 80 (Physical layer) of the hardware abstraction can be built based on the international standards ITU I-series and ITU G-series documents. The second layer 82 (Data Link layer) is defined in the ITU Q.920 through Q.923 documents. The third layer 84 (Network layer) is defined in the ITU Q.930 through Q.939 documents. These specifications taken together define how to build the hardware abstraction block 28 for virtual phone support built on top of an ISDN switch.

Initialization Functions

The following functions are used for initialization and are typically only called system on startup.

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vp_init () Performs general virtual phone initialization such as allocating data and variable initialization. This function is called by the main application once during startup.

vp_init_pbx_type () Performs initialization specific to a particular switch. This function is called automatically by the virtual phone system when the VPAPI function "vp_SetPbxType" is called. Normally, this happens only once at startup.

vp_init_set_type () Performs initialization specific to a specific digital telephone. This function is called automatically by the virtual phone system when the VPAPI function "vp_SetSetType" is called. Normally, this happens only once at startup.

Configuration Control Functions

These functions are used to manage system configuration information between the main application and the virtual phone.

vp_SendPbxType (BYTE resp)
vp_GetPbxType (BYTE *type)
vp_SetPBXType (BYTE type)

The foregoing three functions configure the virtual phone 20 with the current physically connected type of switch 12. After the main application determines which switch is connected, it calls the Set function. The Set function automatically call vp_init_pbx_type ().

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SET_UNKNOWN	Digital set of unknown type connected
SET_ROLM_400	Rolm RP400 set connected
SET_ROLM_240	Rolm RP240 set connected
SET_ROLM_120	Rolm RP120 set connected
SET_ROLM_600	Rolm 600 series set connected
SET_ROLM_300	Rolm 300 series set connected
SET_M1_2616	Meridian 2616 set connected
SET_NOR_7310	Norstar 7310 set connected
SET_NOR_7208	Norstar 7208 set connected
SET_NOR_7100	Norstar 7100 set connected
SET_NOR_7310BLF	Norstar 7310 BLF set connected
SET_NOR_7324	Norstar 7324 set connected

resp The type of data to be transmitted to the serial port 26.

QUERY_RESPONSE	No change, serial packet is due to a query
DELTA_RESPONSE	The state of the virtual phone has changed

vp_SendConnections (BYTE resp)
vp_GetConnections (BYTE *mask)
vp_SetConnections (BYTE mask)

The foregoing three functions configure the virtual phone 20 with a list of physically connected phones. The main application 16 will determine the types of phone units that will have access to the system. Once determined, it calls this functions with a mask representing current connections.

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PHONE_NONE	No phones connected (default)
PHONE_ADJUNCT	The compatible digital phone is connected
PHONE_AUX	The serial link based phone is connected
PHONE_CS1000	The analog conference phone is connected

QUERY_RESPONSE	No change, serial packet is due to a query
DELTA_RESPONSE	The state of the virtual phone has changed

When multiple phones are connected to the system at one time, it is necessary to maintain which of the phones is physically in use. The virtual phone 20 needs this information so that it can direct voice data to the proper phone. Once a phone has "control" of the voice, the virtual phone 20 is responsible for blocking other units from taking dangerous actions (such as terminating the call).

The key elements the virtual phone 20 is concerned with are the current control, and the last touched unit. These values enable the virtual phone to manage call control seamlessly between connected phone units.

vp_SendActivePhone (BYTE) resp)
vp_GetActivePhone (BYTE *type)
vp_SetActivePhone (BYTE type)

The foregoing three functions configure the virtual phone 20 with the current active phone 14. A phone is considered active if the voice path is active, and is directed toward that phone. The active phone is also known to be the phone with "control".

type The phone type ID of the connected phones that currently has control. The phone type must be in the connections mask list.

PHONE_NONE	Idle, no phones have control (default)
PHONE_ADJUNCT	The compatible digital phone has control
PHONE_AUX	The serial link based phone has control
PHONE_CS1000	The analog conference phone has control

resp The type of data to be transmitted to the serial port.

QUERY_RESPONSE	No change, serial packet is due to a query
DELTA_RESPONSE	The state of the virtual phone has changed

vp_SendTouchedPhone (BYTE resp)
vp_GetTouchedPhone (BYTE *type)
vp_SetTouchedPhone (BYTE type)

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type The phone type ID if the connected phones that was last used by the operator. The phone type must be in the connections mask list.

resp The type of data to be transmitted to the serial port.

DELTA_RESPONSE	The state of the virtual phone has changed.
----------------	---

The functions are used to manage all voice related information within the virtual phone 20. Voice active

status, volume, and physical unit on a phone are all maintained.

```
vp_SendVoiceState (BYTE resp)
vp_GetVoiceLevel (BYTE *level)
vp_GetVoiceUnit (BYTE *unit)
vp_GetVoiceVolume (BYTE *volume)
vp_SetVoiceLevel (BYTE level)
vp_SetVoiceUnit (BYTE unit)
vp_SetVoiceVolume (BYTE volume)
```

The foregoing seven functions configure the virtual phone 20 with the current voice status. Whenever the switch 12 activates or deactivates the voice path, these functions are called. Some switches and phones have the ability to activate the voice path at different volumes, and on different units (such as headset or speakerphone).

level When TRUE, the system voice path is active. When FALSE, it's inactive. See vp_GetActivePhone to determine which phone has control of the voice path.

unit The unit on the phone which is in use by the operator.

VOICE_HANDSET	The standard handset found on most phones
VOICE_SPEAKER	The speaker/microphone (found on some phones)
VOICE_HEADSET	An auxiliary headset unit (usually a separate plug in device)

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volume The volume at which voice can be heard through the phone.

VOICE_MUTE	Voice active, but volume muted
VOICE_NORMAL	Normal voice volume
VOICE_LOW	Volume audible, but lower than normal
VOICE_HIGH	Volume higher than normal

resp The type of data to be transmitted to the serial port.

QUERY_RESPONSE	No change, serial packet is due to a query
DELTA_RESPONSE	The state of the virtual phone has changed

Ringer Control Functions

These functions are used to manage all ringer related information within the virtual phone 20. Ringer active status, cadence, and tone during ring are all maintained.

vp_SendRingerState (BYTE resp)
vp_GetRingerLevel (BYTE *level)
vp_SetRingerCadence (BYTE *cadence)
vp_GetRingerTone (BYTE *tone)
vp_SetRingerLevel (BYTE level)
vp_SetRingerCadence (BYTE cadence)
vp_SetRingerTone (BYTE tone)

The foregoing seven functions configure the virtual phone 20 with the current ringer status. Whenever the switch 12 turns the audible ringer

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QUERY_RESPONSE	No charge, serial packet is due to query
DELAT_RESPONSE	The state of the virtual phone has changed

Lamp Control Functions

These functions are used to manage all lamp (LED or light) related information within the virtual phone 20. Many lamps typically exist on a given system. The virtual phone has the facility to store the state of any of these lamps. It is also possible to pass the lamp update information directly to the host system. In this case, the virtual phone just passes the information through without maintaining it.

In the case where the lamp is stored in the virtual phone, any of the functions can be used to read or write data. The functions with the "V" in the name require the virtual phone index of the lamp. The remaining functions work directly with the raw ID. The "Ex" of extended functions allow for multiple bytes of raw ID information.

When the lamp status is not maintained within the virtual phone structures, only the functions working with the raw IDs can be used. These functions will simply pass the update information directly to the host without storing any information within the virtual phone structures.

vp_SendVLampState (BYTE resp, BYTE vid)
vp_SendLampState (BYTE resp, BYTE len, BYTE*rawidlist, BYTE
state)
vp_GetVLampState (BYTE vid, BYTE *state)
vp_SetVLampState (BYTE vid, BYTE state)
vp_SetLampState (BYTE rawid, BYTE state)

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[illegible]

The figure consists of 10 histograms arranged horizontally, each representing a different value of α . The x-axis for all histograms is 'Nodes per Cluster' (ranging from 0 to 10), and the y-axis is 'Frequency' (ranging from 0 to 10). The histograms show that most clusters contain 1 or 2 nodes, with the frequency of single-node clusters being the highest across all values of α .

```
resp The type of data to be transmitted to the serial
port 26.
```

DELTA_RESPONSE	The state of the virtual phone has changed
----------------	---

These functions are used to manage all button and hook switch related information within the virtual phone. A hook switch and many buttons typically exist on a given system. The virtual phone has the facility to store the state of any of these buttons. It is also possible to pass the button press/release information directly to the host system. In this case, the virtual phone just passes the information through without maintaining it.

In the case where the button is stored in the virtual phone, any of the functions can be used to read or write data. The functions with the "V" in the name require the virtual phone index of the button. The remaining functions work directly with the raw ID. The "Ex" of extended functions allow for multiple bytes of raw ID information.

```
vp_SendVButtonState (BYTE resp, BYTE vid)
vp_SendButtonState (BYTE resp, BYTE len, BYTE*rawidlist,
BYTE state)
vp_GetVButtonState (BYTE vid, BYTE *state)
vp_SetVButtonState (BYTE vid, BYTE state)
vp_SetButtonState (BYTE rawid, BYTE state)
vp_SetButtonState (BYTE len, BYTE *rawidlist, BYTE state)
```

```
rawidlist  A list of raw IDs sent from the switch.
           This is used when more than one byte of
           information is needed to reference the
           button.  The "len" parameter is used to
           define the number of bytes in this list.
```

state The State of the button or hook switch. Buttons can be either pressed or released. The hook switch is considered pressed when off hook, and released when on hook.

```

BUTTON_PRESS    Button has been pressed
BUTTON_RELEASE  Button has been released

```

vid The ID within the virtual phone 20 for the button or hook switch. Each Button/Lamp control structure has fields for button information. Only certain buttons/lamps are defined to be as part of the virtual phone. This field is an index into the virtual phone's button/lamp structure. (See section Button/Lamp index descriptions).

resp The type of data to be transmitted to the serial port.

QUERY_RESPONSE No change, serial packet is due to a query

DELTA_RESPONSE The state of the virtual phone has changed

Hook Switch Control Functions

The hook switch is just a button. Button index zero is always fixed to the hook switch. Because of this, the button API calls can be used for hook switch control. However, for simplication sake, a set of API function are provided for direct hook switch control.

vp_SendHookState (Byte resp)
vp_SetHook_State (BYTE state)
vp_GetHookState (BYTE *state)

state The state of the book switch.

HOOK_OFF Off hook (Same as button press)
Hook_ON On hook (Same as button release)

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DELTA_RESPONSE The state of the virtual phone has changed

Display Control Functions

The virtual phone supports the ability to maintain a flexible display. These functions provide the abstraction layer the ability to build the display in a way similar to how the switch puts information on the display.

The abstraction layer calls the "update" functions to send text changes to the display as they are received from the switch. Addressing is either direct (by row and column number), or based on a cursor position. The switch often clears single rows or even the entire display with one command. An API function exists for each of these tasks.

Often, more than one cursor exists for a given display. The abstraction layer passes the cursor index whenever a display update at cursor type command is given. An API command exists to maintain each current cursor position.

When the display has been stable (has not changed) for a given period of time, or the switch sends a "display stable" command, the abstraction layer calls the "vp_dDisplayIsStable" function. This triggers the virtual phone to send the display contents to the host.

vp_SendDisplay (BYTE resp)

Carrier Control Functions

The virtual phone maintains the carrier state of the switch, and the adjunct digital phone. This information is available via the following functions.

vp_SendCarrier (BYTE resp, BYTE device)
vp_SetCarrier (BYTE device, BYTE level)
vp_GetCarrier (BYTE device, BYTE *level)

device The physical device.

CARRIER_DEVICE_SWITCH	The switch
CARRIER_DEVICE_ADJUNCT	The adjunct digital phone

level The carrier level

CARRIER_LEVEL_LOSS	No carrier for the device
CARRIER_LEVEL_GAIN	The device has carrier
CARRIER_LEVEL_UNKNOWN	Carrier state unknown

resp The type of data to be transmitted to the serial port.

QUERY_RESPONSE	No change, serial packet is due to a query
DELTA_RESPONSE	The state of the virtual phone has changed

Pass Through Control Functions

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```
vp_SendPassThroughFlags (BYTE resp)
vp_SetPassThroughFlags (BYTE flags)
vp_GetPassThroughFlags (BYTE *flags)
```

PASS_HOOK	hook switch from digital set
PASS_BUTTON	button presses/releases from digital set
PASS_LAMP	lamp updates from switch
PASS_DISPLAY	display updates from switch
PASS_RINGER	ringer updates from switch

```

QUERY_RESPONSE No change, serial packet is
                due to a query
DELTA_RESPONSE  The state of the virtual
                phone has changed

```

The voice and data channels can be routed normally to the adjunct digital phone, or to another device. These functions control the routing of these bearer channels.

The system may want to instruct the virtual phone to send voice or data information to a unit other than the adjunct phone such as a conference phone or a DSP for processing.

Since the digital data link between the switch and the phone typically provides a voice channel and at least one data channel, these functions use a bit mask to identify which of the channels to control.

vp_SendVoiceMux (BYTE resp)
vp_SetVoiceMux (BYTE devicemask, BYTE unit)
vp_GetVoiceMux (BYTE devicemask, BYTE*unit)

devicemask A bit mask with each bit representing one of the bearer channels to direct with the command

VMUX_VOICE	voice channel
VMUX_DATA	data channel
VMUX_DATA1	primary data channel
VMUX_DATA2	secondary data channel

unit The device where the channel is to be directed.

VMUX_ADJUNCT	Adjust digital telephone
VMUX_AUX	The other connected unit (DSP, conference phone, etc.)

resp The type of data to be transmitted to the serial port.

QUERY_RESPONSE No change, serial packet is due to a query

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DELTA_RESPONSE The State of the virtual
phone has changed

Virtual Phone Host Interface Protocol

Communications between the virtual phone 20 and the external device, i.e. host system, is accomplished via an internally designed custom protocol called the Virtual Phone Host Interface Protocol (VPHIP) 26. Any time the virtual phone changes, a VPHIP packet is sent out to the host reflecting the update to the virtual phone structure. This keeps the auxiliary PC 16 up to date at all times with the current status of the virtual phone.

The auxiliary PC 16 also has the ability to manipulate the virtual phone by sending VPHIP packets across the link. The virtual phone parses the VPHIP packet and calls the appropriate VPAPI function, which in turn may update the virtual phone structure.

The functionality and structure of VPHIP is described as follows:

Packet Format

All packets adhere to the following format:

<u>Length</u>	<u>Description</u>	<u>Value</u>
1 Byte	Header	see note
1 Byte	Packet Length	variable
1 Byte	Packet Description	see below sections
Variable	Packet Data	see below sections

The header byte follows specific rules. Any message originating from the switch 12 has a header of 0x01. Messages from the adjunct phone 14 have header 0x02. Messages from the auxiliary PC 16 have header 0x04. Informational messages (such as PBX type) have header 0x00. Queries, and responses to queries turn on the upper most bit of the header which result in header codes of 0x08, 0x81 and 0x82.

System Information messages

System information packets are used to communicate phone status information between the internal virtual phone 20 and the auxiliary PC 16. All system information packets have a header value of 0x00.

Carrier State

These packet types are used to identify the carrier condition of the switch or the digital telephone.

<u>Byte</u>	<u>Description</u>	<u>Value</u>
0	Header	0x00
1	Packet Length	4
2	Carrier (Switch)	0xB0
3	Carrier Level	
	No Carrier	0
	Carrier	1
	Unknown	2
	Condition	

<u>Byte</u>	<u>Description</u>	<u>Value</u>
0	Header	0x00
1	Packet Length	4

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2	Carrier (Digital Set)	0xB1
3	Carrier Level	
	No Carrier	0
	Carrier	1
	Unknown	2
	Condition	

Adjunct Phone Type

The adjunct phone type packet is used to identify the type of digital phone (if any) that is physically connected to the interface board.

<u>Byte</u>	<u>Description</u>	<u>Value</u>
0	Header	0x00
1	Packet Length	4
2	Adjunct Phone Type	0xF1
3	Phone Index	
	None	0
	Unknown	1
	Rolm RP400	10
	Rolm RP240	11
	Rolm RP120	12
	Rolm RP600	13
	Rolm RP300	14
	M1 2616	30
	Norstar 7310	50
	Norstar 7208	51
	Norstar 7100	52
	Norstar 7310 BLF	53
	Norstar 7324	54
	AT&T 7405	70
	AT&T 7406	71
	AT&T 7407	72

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Current Active Phone

When more than one phone is connected to the interface board at the same time, it is often necessary to know which unit is actively communicating with the switch 12. This is necessary to establish such things as voice routing, and button filtering. This packet returns the physical phone description that is currently active.

<u>Byte</u>	<u>Description</u>	<u>Value</u>
0	Header	0x00
1	Packet Length	4
2	Active Phone Type	0xF2
3	Unit Index	
	None	0x00
	Adjunct Digital Set	0x01
	Auxiliary	0x02
	Conference Phone	0x04
	future use	0x08...

Last Touched Phone

When more than one phone is connected to the interface board at the same time, the user may operate either unit to make and receive calls. Knowing which physical unit was last touched enables the virtual phone 20 to route voice and control to the appropriate unit.

<u>Byte</u>	<u>Description</u>	<u>Value</u>
0	Header	0x00
1	Packet Length	4
2	Touched Phone Type	0xF3

3	Unit Index	
	None	0x00
	Adjunct Digital Set	0x01
	Auxiliary	0x02
	Conference Phone	0x04
	future use	0x08...

Physical Connections

The virtual phone 20 may support several controlling and/or monitoring devices simultaneously. This command is used to transfer the current configuration information. The connection information is stored as a bit mask providing space for up to 8 physical devices.

<u>Byte</u>	<u>Description</u>	<u>Value</u>
0	Header	0x00
1	Packet Length	4
2	Physical Cncts Type	0xF4
3	Connection Mask	
	None	0x00
	Adjunct Digital Set	0x01
	Auxiliary	0x02
	Conference Phone	0x04
	future use	0x08...

Messages from the switch

All messages originating from the switch 12 have a header value of 0x01.

Voice Status

The Voice Status packets are used to supply the current voice status to the auxiliary PC 16. The physical unit being used, and the volume are also supplied.

00000000 00000000 00000000 00000000

<u>Byte</u>	<u>Description</u>	<u>Value</u>
0	Header	0x01
1	Packet Length	5
2	Voice Enable	0x10
3	Unit	
	Handset	0x01
	Speaker	0x02
	Headset	0x04
4	Volume	
	Mute	0
	Normal	1
	Low	2
	High	3

<u>Byte</u>	<u>Description</u>	<u>Value</u>
0	Header	0x01
1	Packet Length	3
2	Voice Disable	0x11

The Voice Enable command (0x10) explicitly activates the voice channel regardless of unit state. Voice Disable (0x11) explicitly de-activates voice. The Voice Status command (0x12) is a combination of the two where the presence of a bit in the unit mask is used to determine whether or not voice is active.

<u>Byte</u>	<u>Description</u>	<u>Value</u>
0	Header	0x01
1	Packet Length	5
2	Voice Status	0x12
3	Unit	
	Handset	0x01
	Speaker	0x02
	Headset	0x04

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4	Volume	
	Mute	0
	Normal	1
	Low	2
	High	3

Ringer Status

The ringer status packets are used to supply ringer status to the auxiliary PC 16. In addition to ringer status, the cadence and ring tone are also supplied. In some switches, the ringer turns on and off with the audible sound while the calling party is attempting to connect. It may be beneficial to leave the ringer in the "on" state and have the virtual phone use the "cadence off" condition between audible rings. This will give feedback similar to that of using the LED for incoming call status.

<u>Byte</u>	<u>Description</u>	<u>Value</u>
0	Header	0x01
1	Packet Length	5
2	Ringer Active	0x20
3	Cadence	
	Off	0
	On	1
	#2	2
4	Tone	
	Off	1
	A	2
	B	3
	C	4
	D	5
	E	6
	F	7
	G	8
	H	9

<u>Byte</u>	<u>Description</u>	<u>Value</u>
0	Header	0x01

1	Packet Length	3
2	Ringer Inactive	0x21

Lamp Status (Generic)

The Lamp status packet is used to supply lamp (LED) information to the Auxiliary PC 16. The internal virtual phone lamp ID (not the switch's raw ID), and the flash rate are passed in the packet.

<u>Byte</u>	<u>Description</u>	<u>Value</u>
0	Header	0x01
1	Packet Length	5
2	Lamp Update	0x30
3	Flash Rate	
	Off	1
	On	2
	Flash	3
	Flutter	4
	Wink	5
	Flicker	6
	Misc1	7
4	Lamp ID	
	Prime Line	16
	Others	17

Lamp Status (Raw)

The Raw lamp status packet is used to supply lamp (LED) information to the auxiliary PC. The raw ID received from the switch (not the internal virtual phone ID), and the flash rate are passed in this packet.

In the case where lamps have multiple bytes for the ID, the additional bytes are placed at the end of the packet and the length is changed accordingly.

<u>Byte</u>	<u>Description</u>	<u>Value</u>
0	Header	0x01

1	Packet Length	4 + number of raw ID bytes
2	Lamp Update (Raw)	0x31
3	Flash Rate	
	Off	1
	On	2
	Flash	3
	Flutter	4
	Wink	5
	Flicker	6
	Misc1	7
4	Lamp raw ID byte #1	
5	[Lamp raw ID byte #2]	

Display Status

The Display status packets are used to supply display information to the auxiliary PC. These packets allow for portions of the display to be updated as they are received from the switch. The basis display packet supplies text and position information (the length can be extracted from the packet length byte). There are other special packets that can be used for scrolling of flashing characters on the auxiliary PC.

<u>Byte</u>	<u>Description</u>	<u>Value</u>
0	Header	0x01
1	Packet Length	5 + (length of text)
2	Display Update	0x40
3	Row	variable
4	Column	variable
5...	Text	"variable string"

The Clear Display packet can also be used to clear the entire display, or a single row of the display.

<u>Byte</u>	<u>Description</u>	<u>Value</u>
0	Header	0x01
1	Packet Length	4
2	Clear Display	0x41
3	Row	
	All rows	0
	Single row	row number

Messages from the Phone

All messages originating from the PBX 12 have a header value of 0x02.

Button Status (Generic)

The virtual phone 20 is configured with a set of generic buttons used across all switches. These buttons (and associated lamps, if any), have fixed identifiers. Only the buttons with identifiers assigned to the virtual phone function with this command.

The Button status packets are used to supply button press/release information originating from the adjunct phone to the auxiliary PC.

<u>Byte</u>	<u>Description</u>	<u>Value</u>
0	Header	0x02
1	Packet Length	4
2	Button Press (Generic)	0x50

3	ID	
	Hook Switch	0 (OFF hook)
	Hold	1
	Transfer	2
	Release	3
	Key Pad (0-9,*,#)	4-15
	Prime Line	16
	Others	17

<u>Byte</u>	<u>Description</u>	<u>Value</u>
0	Header	0x02
1	Packet Length	4
2	Button Press (Generic)	0x51
3	ID	
	Hook Switch	0 (ON hook)
	Hold	1
	Transfer	2
	Release	3
	Key Pad (0-9,*,#)	4-15
	Prime Line	16
	Others	17...

Button Status (Raw)

All buttons on all phones have a defined raw id. This command is used to transmit this raw id across the interface. Either this command, or the Generic button status command can be used to transmit button state changes.

In the case where buttons have multiple bytes for the ID, the additional bytes are placed at the end of the packet and the length is changed accordingly.

The Button status packets are used to supply button press/release information originating from the adjunct phone to the auxiliary PC.

All messages originating from the auxiliary PC 16 have a header value of 0x04. In many cases, the host 16 may emulate commands from the switch or the digital telephone. Any of the previously defined packets may be sent from the host. The header signs the virtual phone as to the source of the command so the appropriate action may be taken.

Button Control and Status

The virtual phone 20 is configured with a set of generic buttons used across all switches. These buttons (and associated lamps, if any), have fixed identifiers. Only the buttons with identifiers assigned to the virtual phone function with this command.

The auxiliary PC 16 uses the button control and status packets to transmit button change requests to the virtual phone. The effect of these packets on the virtual phone 20 is the same as if buttons were pressed on the adjunct phone directly. This protocol allows for auxiliary button press/release emulation.

Regardless if button changes originate on the adjunct phone or the auxiliary PC 16, the virtual phone 20 maintains the current button state. Whenever a button state changes, these same packets are used to transmit the new status to the auxiliary PC 16.

System State

When the host system is ready to receive messages from the virtual phone, it sends the enable command. This causes the virtual phone to send all virtual phone changes and system messages to the host via the host interface protocol. When the host is disabled, the virtual phone

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still maintains the state phone state, it just blocks the information from being transmitted to the host.

<u>Byte</u>	<u>Description</u>	<u>Value</u>
0	Header	0x04
1	Packet Length	4
2	System State	0x90
3	Level	
	Disabled	0
	Enabled	1

Pass Through Flags

The host system has the ability to request certain types of messages to be passed or blocked between the switch and the digital telephone. It is the responsibility of the virtual phone to maintain these flags and send only the specified packets between the units.

If the bit in the mask is set, the packet types are passed through. If cleared, they are blocked.

<u>Byte</u>	<u>Description</u>	<u>Value</u>
0	Header	0x04
1	Packet Length	4
2	Hook Switch Up	0x91
3	Flags	
	Hook Switch from Set	0x01
	Buttons from Set	0x02
	Lamp updates from switch	0x04
	Display from Switch	0x08
	Ringer from Switch	0x10

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Dial Command

The host can request the virtual phone to dial a given string of digits. The virtual phone implements the button presses/releases and the necessary delays based on the parameters to the dial command. The dial string can contain any of the keypad buttons and the comma. The keypad buttons represent themselves and the commas represents a specified delay.

The digit duration (byte 3) of the command represents the length in milliseconds that the key is to be held down. The inter-digit duration is the length between key presses. The pause duration is the length of the pause (comma) character.

When the virtual phone completes the dialing, it sends a 3 byte version of this packet back to the host with only the header, length, and commands bytes.

<u>Byte</u>	<u>Description</u>	<u>Value</u>
0	Header	0x04
1	Packet Length	6+# of digits in dial string
2	Dial Command	0x93
3	Digit Duration	
4	Inter-Digit duration	
5	Pause Duration	
6	Dial string	

Bearer Channel Direction

Either the abstraction layer or the host system has the ability to direct the voice mux to their desired device.

This device is typically either the adjunct digital phone, or an auxiliary unit. The virtual phone maintains the direction of the voice mux. In addition to voice, a number of additional channels can be controlled. This command is used to transfer mux direction status of all the bearer channels.

If the bit in the mask is set, the mux is directed to the auxiliary unit. If cleared, the channel is directed to the adjunct digital telephone.

<u>Byte</u>	<u>Description</u>	<u>Value</u>
0	Header	0x04
1	Packet Length	4
2	Voice Mux	0x93
3	Device Mask	
	Voice	0x01
	Data	0x02
	Data1	0x02
	Data2	0x04

Queries

The auxiliary PC 16 can query the virtual phone 20 for current status at any time. This is done by sending a command symmetric to the receive command for each status type. These commands are the same as the receive commands with the exception of the upper most bit of the header byte. When this bit is high, the virtual phone interprets this as a query and automatically responds with the current status.

For example, if the auxiliary PC 16 is requesting the ringer status, it sends the packet [81 04 20##] (where ## is irrelevant data). The virtual phone 20 will respond by

transmitting [01 04 20 ##] or [01 04 21] (where ## is valid data) back to the auxiliary PC.

The valid query command IDs are:

0x54 Query Hook Switch Status
0x91 Query Pass Through Flags Status
0xB0 Query Switch Carrier Status
0xB1 Query Digital Phone Carrier Status
0x10 Query Voice Status
0x20 Query Ringer Status
0x30 Query Lamp Status
0x40 Query Display Status
0x50 Query Button Status
0xF0 Query Switch Type
0xF1 Query Adjunct Phone Type
0xF2 Query Current Active Phone
0xF3 Query Last Touched Phone

In connection with the foregoing description, Table I lists the data structures of virtual phone 20 and Table II lists various serial commands.

Table I - Virtual Phone Structures

```
typedef struct                                /*Virtual Phone Voice
{                                              Structure*/
    BYTE active;                             /*1=active 0=not active*/
    BYTE unit;                               /*mask active unit UPV_???? */
    BYTE volume;                             /*voice mute, low, high, etc
                                              */
{VP_VOICE;

typedef struct                                /*Virtual Phone Ringer
                                              Structure*/
    BYTE active;                             /*1-active0-not active*/
    BYTE cadence;                           /*list of current cadence
                                              type*/
    BYTE tone;                              /*list of current tone type*/
{VP_RINGER;
```

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```
typedef struct                                /*virtual phone display
                                           structure*/

    BYTE row;                                /*Current row for this
                                           cursor*/

    BYTE col;                                /*Current column for this
                                           cursor*/

}VP_CURSOR;

typedef struct                                /*Virtual Phone Display
                                           Structure*/

{VP_CURSOR;

typedef struct                                /*Virtual Phone Display
                                           Structure*/

    BYTE grid[VPD_MAX
ROWS][VPD_MAXCOLS];                        /*The display text*/

    BYTE cursor                                /*current cursors*/
{VPD_MAXROWS};

    BYTE NumRows;                            /*Number of Rows on this
                                           page*/

    BYTE NumColumns                          /*Number of Columns on this
                                           page*/

    BYTE NumCursors;                        /*Number of available
                                           cursors*/

    BYTE IsStable;                          /*True if the display has
                                           stablized*/

    BYTE IsClear;                          /*True if the display is
                                           currently clear*/

{VP_DISPLAY;

typedef struct                                /*Virtual Phone Button/Lamp
                                           Structure*/

    BYTE deviceMask;                        /*mask showing which of next 4
                                           are valid*/
```

```
BYTE pressID;           /*ID of button press info*/
BYTE releaseID;         /*ID of button release info*/
BYTE lamp1ID;           /*ID of first lamp info*/
BYTE lamp2ID;           /*ID of second lamp info*/
BYTE buttonState;       /*state of button; 1=down 0-
                        up*/

BYTE lamp1State;        /*state of first lamp*/
BYTE lamp2State;        /*state of second lamp*/
{VP_BUTTON;
typedef struct           /*Main Virtual Phone
                        Structure*/
{
    VP_VOICE voice;      /*voice status*/
    VP_RINGER ringer;    /*ringer status*/
    VP_DISPLAY display;  /*LCD display status*/
    BYTE Hook Switch     /*Hook switch status*/
    BYTE num_buttons;     /*number of buttons actually
                        in use*/

    VP_BUTTON button     /*button/lamp status*/
    [VP_MAXBUTS];

    BYTE StandAlone;      /*Operate without Digital
                        set*/

    BYTE SwitchType;      /*Type of switch connected*/
    BYTE DigSetType;      /*Type of configured digital
                        SET, if any

    BYTE Connections;     /*Which Phone Units are
                        physically connected*/

    BYTE ActivePhone;     /*Which Physical Phone Unit is
                        active

    BYTE TouchedPhone;    /*Which Physical Phone Unit
                        was touched

    BYTE Carrier(2);      /*0=switch 1=digital set*/
```

00947594 000004

```

    BYTE PassThroughFlags;    /*event block flags*/
    BYTE VoiceMux;            /*Bearer channel direction*/
{ VIRTUAL PHONE;

```

Table II - Brief Host Command List

<u>Description</u>	<u>Header</u>	<u>Length</u>	<u>Command</u>	<u>Data1</u>	<u>Data2</u>	<u>Data3</u>
Voice Enable	P	05	10	Unit		
Voice Disable	P	03	11			Volume
Voice State	P	05	12	Unit		Volume
Ringer Enable	P	05	20	Cadence	Tone	
Ringer Disable	P	03	21			
Lamp (Generic)	P	05	30	status		
Lamp (Raw)	P	04+count	31	status	41 ID #1	[raw ID#2]
Display	P	05+text len	40	row	col	text...
Display Clear	P	03	41			
Button Press (Gen)	SHX	04	50			
Button Release (Gen)	SHX	SHX	04	51ID		
Button Press (Raw)	SHX	03+count	52	raw ID #1	[raw ID #2...]	
Button Release (Raw)		SHX	03+count	53 raw ID #1	[raw ID #2]	
Hook Switch Up	SHX	03	54			

P-PPBX generated message	note 1: parameters for dial command
S-SET generated message	data1: digit duration (high byte)
H-Host generated message	data2: digit duration (low byte)
X-Firmware system generated message	data3: inter-digit duration (high byte) data4: inter-digit duration (low byte)

data5: pause duration (high
byte)
data6: pause duration (low
byte)
data7:? dial string

The system of the present invention can be generalized in the form of the system of Fig. 5 including media control proxy 100, communication switch 102 and communication device or terminal 104. Switch 102 is analogous to PBX 12 in Fig. 1, terminal 104 is analogous to phone 14 in Fig. 1 and media control proxy 100 is a generalized form of the virtual phone 18 of Fig. 1. The Media Control Proxy (MCP) 100 is used as a gateway between some communications switching system, i.e. switch 102, and some terminal, i.e. terminal 104. The main purpose of the MCP is to bridge any gap in the communication protocols between the server device (the switch) 102 and the client (the terminal 104).

Communication device 104 is any device which originates and/or receives a media including audio and visual, and device 104 can be a physical terminal or an emulation of a physical terminal in computer hardware including an application residing in a system.

In the minimum configuration of Fig. 5, the MCP 100 resides between the switch 102 and the terminal 104. Bearer channel data (voice, video, etc) is passed through by the MCP 100 on channels 110 and 112. The information on the control channels 114 and 116 is processed and converted to a protocol understood by the terminal 104. Depending on the type of terminal connected, this could be a proprietary protocol specific to the terminal, or it could be the MCP's standard protocol designed to communicate with a wide range

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of devices. Control channel 116 also may be viewed as an application program interface (API).

The MCP 100 interprets the information it receives from the control channel 114 of the switch 102 and maintains the state of the terminal 104 as defined by the switch 102. As far as the switch 102 is concerned, the MCP 100 is the terminal 104. The MCP 100 also transmits data on the control channel 114 to the switch 102. It does this in the protocols native to the switch 102. The switch 102 interprets any messages coming from the MCP 100 as those coming from the terminal 104.

The MCP 100 can be configured to function in many different ways. The main point is that it has the ability to communicate with not only the native terminal for the switch, but that it can communicate with an unlimited selection of terminals or communications devices. The fixed (and sometimes proprietary) control protocol used in the original connection between the switch and native terminal is converted to whatever communications method is necessary to support any given terminal.

The type of terminal that may be connected to the MCP 100 is so flexible that the type of medium in which the data and control channels reside is also limitless. A direct proprietary connection is possible, as is a connection over a computer bus. It is also possible to route data and control channel information across new or existing networks. Means of wireless communications is supported. In fact, this system is set up to be configurable to operate with any terminal in whichever transport is desired. The MCP 100 handles the data preparation for any such configuration.

It is therefore apparent that the present invention accomplishes its intended objects. A telephone communication system is provided which converts proprietary PBX or external application protocols into a common format and thus functions as a protocol interpreter between proprietary switching system protocols and the protocols of various applications. The virtual phone generic interface of the present invention is configurable and works independently of a specific type of integration and provides a common interface between any of the digital phone switches and any number of end devices. Changes in the virtual phone interface are communicated to an external processor which, in turn, can command changes in the virtual phone interface.

While an embodiment of the present invention has been described in detail, that is done for purposes of illustration, not limitation.

What is claimed is:

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